PATENT SPECIFICATION 1 383 364

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(19)

(54) APPARATUS AND METHOD FOR BENDING ELONGATED OBJECTS

(71) We, COJAFEX N.V., a company organised under the laws of Netherlands of Glashaven 10c, Rotterdam, Holland, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement: —

The invention relates to controlling the cross section of tubes and other elongated objects which are being progressively bended, the bending being effected by heating the object in a narrow zone transverse to the longitudinal dimension of the object and by applying a bending moment to the object in said zone.

As described for instance in the Czecho-Slovakian Patent Specification 111.259 the bending moment can be obtained by means of a swinging bending arm, to which the object (hereinafter called "tube" for the sake of convenience) urged in the longitudinal direction, is fastened beyond the heated zone in such a manner as to be unable to rotate, the distance between the place of fastening and the pivoting point of the bending arm corresponding to the desired bending radius of the tube.

The line joining the heated zone with the centre or pivot of bending curvature should be perpendicular or substantially perpendicular to the longitudinal axis of the unbent part of the tube. It is to be noted that instead of a swinging arm other means may be used for bending the tube beyond the heating zone along a track of the radius desired so as to produce in the heated zone a bending moment which causes in said zone a deformation of the tube. In the heating zone the temperature of the material is increased sufficiently to allow deformation, but ahead and beyond said zone the tube, due to its lower temperature (obtained for instance beyond said zone by additional cooling), is to be considered as rigid.

In the heating zone the material at the inner side of the bend is compressed during bending; at the outer side it is stretched. As will be known, the innerside and more so the outerside of the material at the bend tends to displace towards the centre line of the object, so that a round tube tends to take on an oval cross-sectional shape, which is generally undesired. Especially with conventional bending of tubes, either heated or cold, this deformation is a familiar phenomenon to remedy which, means such as saddles, filling with sand or a mandrel are applied. The smaller the radius of bending the larger the deformations in general will be. It is an object of the invention to provide a method and a device by which the cross-sectional shape of the object to be bent can be controlled so that for instance the oval deformation of a bent tube can be either completely or to a large extent prevented, whereas under certain circumstances it will even be possible to give a round tube an oval cross-sectional shape, of which the major axis lies in the plane of bending.

As will be further described below, this object is achieved by having the heating zone arranged in a specific place and/or direction with respect to the centre of the bending curvature in which the tube is bent, in such a manner that the plane of the heated zone, or the plane of part of that zone, will not pass through said centre.

According to the present invention we provide a method of controlling the cross-section of an elongated object while a longitudinal force is being applied to push the object progressively past guide means through a narrow transverse heating zone and while a bending moment is applied to the object in said zone, which comprises

locating the heating zone with respect to the centre of the curvature in which the tube is being bent, so that at least part of the heating zone lies in a plane transverse to the longitudinal axis of the unbent object, which plane does not pass through said centre. The invention also embraces apparatus comprising means for longitudinally moving an elongated object to be bent progressively past a heating device heating a narrow transverse zone; and means for guiding the object beyong said heating device on a radius about a centre of bending curvature; the heating device being arranged in such a way that at least part of the heating zone lies in a plane transverse to the longitudinal axis of the object to be bent, which plane does not pass through said centre.

Since devices are known, in which bending in the general manner described in the introductory part of this description can be accomplished, in the following description only the principle of the invention will be elucidated with the aid of the accompanying diagrammatic drawings, in which:

FIGURE 1 shows the basic principles applied with the above mentioned devices, to serve as starting-point for an explanation of the invention.

The tube chosen as an example to be bent is moved forward by guiding means 3 in the direction of the arrow past a heating device (not shown), by which the tube is heated in the narrow zone indicated by 2*b* to a temperature at which the tube can be deformed as desired. Beyond the place of heating the section 2*c*, which if need be is cooled by a cooling device (not shown), is guided in a circular path around the point 1, by virtue for instance of the section 2*c* being fastened without being able to rotate, to a bending arm 5, rotatable about point 1. Together with the bending arm 5, the already bent portion of the tube 2*c* constitutes a practically rigid assembly, providing a theoretical lever, which remains constantly perpendicular or substantially perpendicular to the longitudinal axis of the object to be bent. The heated zone 2*b* is situated in this Figure in the plane 4 which passes through the centre of rotation 1 and is perpendicular to the centre line of the unbent tube section 2*a*.

During the bending operation compression will occur at the inner side of the bend (2*e*) and stretching will occur at the outer side (2*d*), whereas somewhere between them a neutral zone is situated with practically no compressing or stretching.

Since the material of the heated zone in the inner side of the bend and in the outer side of the bend will resist lengthwise alteration the parts 2*e* and 2*d* tend to displace towards the centre line of the tube, thus causing ovality of the tube.

However, if the heated zone (see Fig. 2) is displaced in a forward direction, that is the direction in which the tube is moved, so that the heated zone in the Figure will be situated above plane 4 in the drawing, there will be set up in the heated zone in addition to the longitudinal force P a transverse force D acting towards the left, which tends to keep the tube wall at 2*e* away from the centre line of the tube, but at 2*d* will try to move the tube wall towards the centre line of the tube.

If on the other hand (see Fig. 3) the heating zone is displaced backwards, so that it will be situated in the Figure below the plane 4, there will be set up in the heated zone in addition to the longitudinal force P a transverse force D acting towards the right, which at 2*d* will try to keep the tube wall away from the centre line of the tube, but at 2*e* will try to move the tube wall towards the centre line of the tube.

By the arrangements indicated in Figs. 2 and 3 deformation of a round tube or in general a sideways "shrinking" of a profile can only be counteracted effectively if a difference in resistance against such a deformation exists between the wall parts at the inner side of the bend and the outer side of the bend of the object. Such differences may result from asymmetry of the cross-section of the object or by an unequal heating of the inner side and the outer side of the bend.

With a symmetrical cross-sectional profile, for instance a tube having an even wall thickness and with symmetrical heating, as in the great majority of cases, the arrangement according to Fig. 4 can be applied. In this arrangement the centre of the heated zone is situated practically in the plane 4, which is perpendicular to the longitudinal axis of the unbent tube and passes through the bending centre 1, but the plane of the heated zone forms an angle with the plane 4, so that in the Figure, 2*e* will be situated above and 2*d* below said plane.

As a result of this arrangement a transverse force D′ directed outwards will act on section 2*e*, and a transverse force D″ directed outwards will act on section 2*d*, counteracting the tendency of both said sections to be displaced towards the centre line of the tube. Under certain circumstances even an opposite ovality of the tube may be attained, in which the major axis of the oval becomes situated in the plane of the drawing.

Besides the arrangements indicated in Figs. 2 to 4, arrangements may also be applied which can be regarded as a combination of the same, for instance an

arrangement in which besides an inclination of the heated zone according to Fig. 4 a displacement of the same according to Fig. 2 or 3 is applied. Fig. 5 shows an example of an arrangement in which the heating zone is partly situated in plane 4, and partly, i.e. at the outer side of the bend, is slanted with respect to said plane.

If desired the heating zone may also be slanted to the other side than indicated in Fig. 4, i.e. if the normal tendency towards ovality of a tube to be bent is to be increased. By application of the invention with the bending of a tube or other elongated objects the cross-sectional profile of same may thus be controlled within certain limits; it will be appreciated that the most important of the possbilities thus attained is keeping a round tube perfectly round during bending.

A device in which the method of the invention is applied will be characterized in that the heating device, by which the heated zone of the elongated object to be bent is obtained, will be arranged in such a manner with respect to the plane perpendicular to the longitudinal axis of said object and passing through the centre of bending, that in the zone of bending the desired cross-sectional profile is attained or maintained. Since the position of the heating device with respect to said plane for different cases, for instance with a different radius of bending, must be different, it is desirable to make the heating device adjustable with respect to its support, which support will generally be formed by the guiding device for the still unbent part of the object.

The adjustment of the heating device may be performed automatically in response to the degree of ovality which is observed by a sensing device during the bending operation.

The heating device can be of various types and heating of a narrow zone of the object may be accomplished for instance by electric induction heating, by radiation or by convection. The method of heating should be suited to the material of the object to be bent, which can for instance be of metal, glass, or a suitable plastics material.

WHAT WE CLAIM IS:—

1. Method of controlling the cross-section of an elongated object while a longitudinal force is being applied to push the object progressively past guide means through a narrow transverse heating zone and while a bending moment is applied to the object in said zone, which comprises locating the heating zone with respect to the centre of the curvature in which the tube is being bent, so that at least part of the heating zone lies in a plane transverse to the longitudinal axis of the unbent object, which plane does not pass through said centre.

2. Method according to Claim 1, wherein said transverse plane is spaced from, but parallel to the plane which is perpendicular to the longitudinal axis of the unbending object and passes through the centre of bending curvature.

3. Method according to Claim 1, wherein said transverse plane makes an angle with the plane which is perpendicular to the longitudinal axis of the unbent object and passes through the centre of bending curvature.

4. Method according to Claim 3, wherein said transverse plane is inclined with respect to the plane passing through the centre of bending curvature in such a way that the zone of heating at the inner side of the bend is ahead of the zone of heating at the outer side of the bend, in the direction of the progressive movement of said object.

5. Method according to any preceding Claim wherein two transverse planes pass through the heating zone.

6. Method of controlling the cross-section of an elongated object during bending, substantially as described with reference to Figures 2 to 5 of the accompanying drawings.

7. Apparatus for carrying out the method of any preceding Claim comprising: means for longitudinally moving an elongated object to be bent progressively past a heating device heating a narrow transverse zone; and means for guiding the object beyond said heating device on a radius about a centre of bending curvature; the heating device being arranged in such a way that at least part of the heating zone lies in a plane transverse to the longitudinal axis of the object to be bent, which plane does not pass through said centre.

8. Apparatus according to Claim 7, wherein the heating device is adjustably connected to a support therefor.

9. Apparatus according to Claim 8, wherein a sensing device responsive to ovality of the object supplies a signal for automatic adjustment of the heating device.

10. Apparatus according to Claim 7, substantially as described and shown in Figures 2 to 5 of the accompanying drawings.

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2 SHEETS This drawing is a reproduction of the Original on a reduced scale
Sheet 1

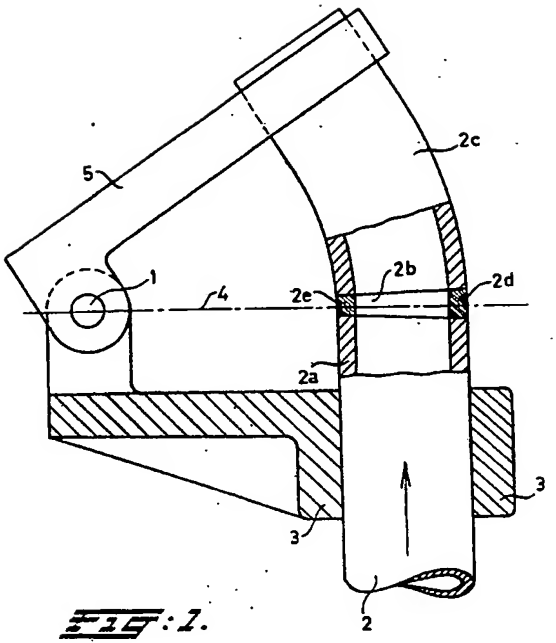

FIG: 1.

1383364 COMPLETE SPECIFICATION
2 SHEETS This drawing is a reproduction of the Original on a reduced scale
Sheet 2

FIG. 2.

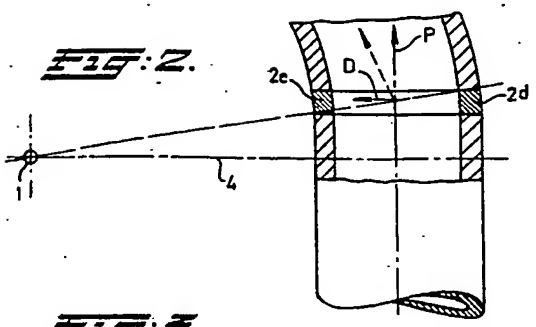

FIG. 3.

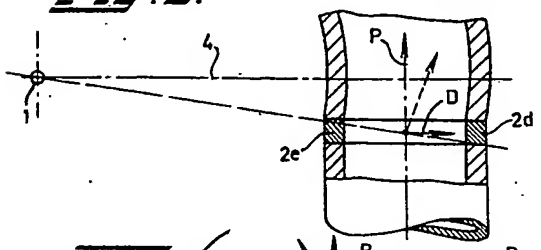

FIG. 4.

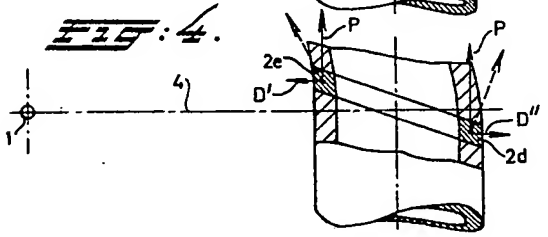

FIG. 5.